FERC Showcases DE Success in Federal Buildings:

DE System Built to Meet Future Electric and Thermal Energy Needs

Figure 1. Union Center Plaza IV (FERC Headquarters) from the south face

Federal facilities are often cited as strong candidates for energy-efficient distributed energy (DE). The Federal Energy Management Program notes that DE, including cooling, heating, and power (CHP) systems, could make significant contributions toward our energy-conservation and emissions-reduction goals while saving the government money.

The Federal Energy Regulatory Commission (FERC) showcases the success of DE, attaining high visibility in the nation's capital. In 1995, FERC leased the newly-built Union Center Plaza IV office building in Washington, DC, as its new headquarters. Working closely with the General Services Administration to develop an energy-efficient building plan, FERC set an energy efficiency goal of 18 kW/ft^2/year. Union Center Plaza IV is an 850,000 square foot (ft^2), 11-story office building that uses a hybrid gas-electric chiller system and other energy-conserving measures to meet the tenants' comfort, energy efficiency, and environmental goals. These measures have cut the building's energy cost per square foot well below the cost for other office buildings in the area.

As is the case with most office buildings, occupancy at FERC's headquarters is concentrated between 7:30 am and 5:00 pm weekdays. As part of the lease agreement, the building's HVAC system is scheduled to operate between 6:00 am and 6:00 pm Monday through Friday. Anticipating growth in computer and Internet usage, the building plan also required flexibility and redundancy in data, communications, and power system infrastructure, and called for a 25 percent buffer in power capacity.

System Technical Overview

The building plan projected a cooling load of about 1,550 tons (5,425 kW), resulting in a 1,900-ton (6,650 kW) chiller plant when accounting for a buffer for future connected load growth. The actual loads are much less than anticipated so the plant is nearly 100 percent redundant for its current occupant. The HVAC plant installed includes a centrifugal chiller, gas-fired absorption unit, and electric resistance units to provide heating.

Project Overview

LOCATION

Union Center Plaza IV Building
Washington, DC

DATE INSTALLED

1995

FACILITY

850,000 ft^2 (gross)

NAICS Code 9211: Executive, Legislative, and Other General Government Support

ELECTRIC & THERMAL

- 929-ton (3,251 kW) electric chiller
- 971-ton (3,398 kW) dual-fuel-fired double-effect absorption chiller-heater
- 2 heat exchangers (9.8 MMBtu/h each)

ANNUAL ENERGY SAVINGS

$61,000

PAYBACK

6 year payback on absorption chiller

ENVIRONMENTAL BENEFITS

- 1,987 lbs NO_x avoided
- 6,146 lbs SO_2 avoided
- 882,329 lbs CO_2 avoided

UNIQUE ASPECTS

- Energy efficiency goal of 18kWh/ft^2/yr
- 25% buffer in power capacity to accommodate growth
- 2.4kW photovoltaic system on roof provides supplemental power

System Design

Early in the design phase, Boland Trane (a local distributor) and Washington Gas began working with contractors to evaluate alternative chiller plant design options. They suggested that a direct-fired, double-effect absorption chiller-heater replace one of the two centrifugal units specified in the preliminary design. They also urged using the heating capability of the absorber rather than the electric resistance heat specified in the preliminary plan since resistance units would cause costly winter electricity peak demand. The design engineers ran several comparative computer analyses of the hybrid and all-electric chiller plant using the loads dictated by the building plan: an annual coil load of 28,319 million Btu (MMBtu) (8,299,932 kWh) for cooling and 855.7 MMBtu (250,769 kWh) for heating. After evaluating three options, the engineering team decided to use one high-efficiency 0.6 kW/ton centrifugal chiller and one gas-fired absorption unit. Heating was to be provided by electric resistance units in the air-handling units (AHUs) and terminal variable air volume (VAV) boxes. After the first few years of operation, however, it was decided to adapt the absorption unit to provide heating, which indeed proved to be more cost-effective than the electric heating. Figure 2 illustrates the configuration of the central plant and air distribution system at FERC.

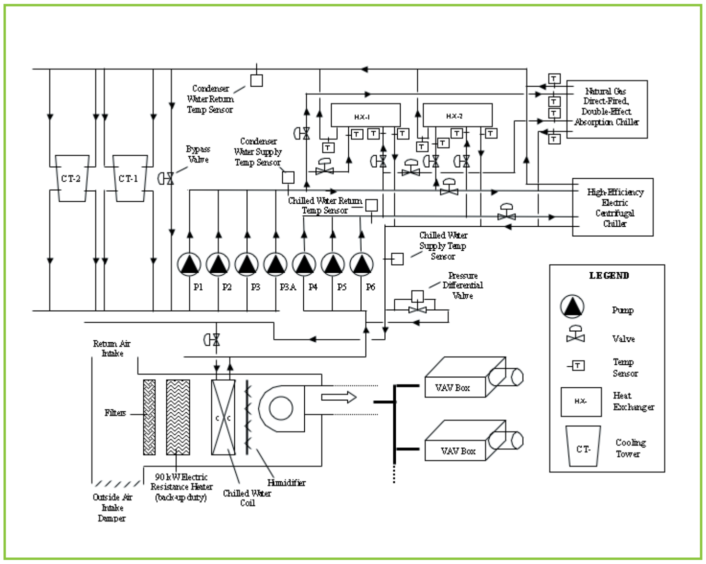


Figure 2. Schematic of central plant and air distribution system at FERC

System Performance

When FERC's building engineering staff began operating the building in October 1995, they were not yet familiar with using an absorption chiller rather than an electric chiller to take advantage of peak shifting. The building also needed fine-tuning to optimize efficiency. This fine-tuning—adjusting control set points and timetables, balancing airflow and pressures, and optimizing chiller plant operations—took three years. In that time, the building engineering staff learned to optimize the complex system. They now limit on-peak electricity demand and ensure that maximum peak does not occur during on-peak hours between June and October. The absorption chiller is used for the bulk of the cooling load; the electric chiller is only used during extremely hot weather, and in the early mornings to "jumpstart" the cooling system while electric rates are low. For the brief periods when heating is needed, the absorber is used instead of the expensive electrical heating elements in the ducts. These strategies have yielded significant energy savings.

Figure 3 compares the total actual and avoided kWh consumption costs by month. Figure 4 compares projected and actual kW demand charges by month. These figures help to illustrate that the greatest portion of savings generated by the hybrid system comes from reducing maximum demand in winter, and maximum demand and on-peak demand in summer.

Figure 3. Comparison of actual and avoided kWh consumption costs by month

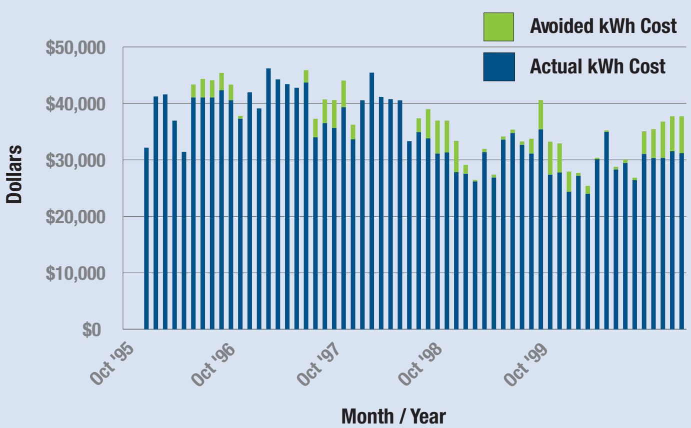
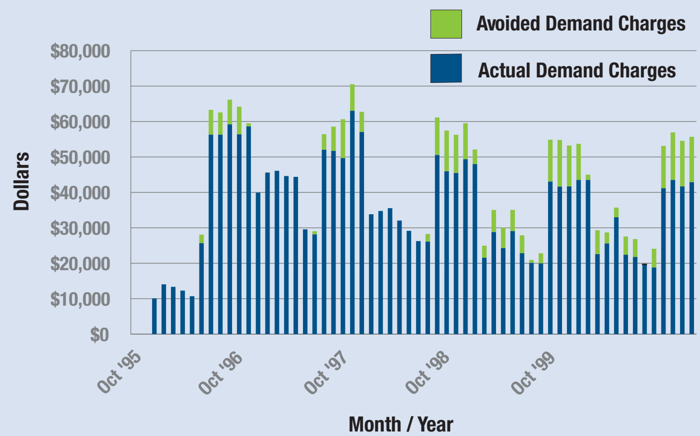


Figure 4. Comparison of actual and avoided kW demand costs by month



Financing

The energy-saving HVAC installation at FERC's headquarters was accomplished utilizing a government solicitation. FERC worked with the General Services Administration to develop a standard Solicitation for Offer (SFO) for this large Federal project. Project first cost for the HVAC system was estimated at $5,367,950 (not including air-handling units and variable air volume boxes). Greenebaum and Rose Associates, the building developer that was selected and current owner of the building, financed the project through a straight short-term construction financing bank loan. A rebate in the amount of $312,500 was provided by Washington Gas to help the project meet return on investment criteria. PEPCO, the local electric utility, provided a $600,000 rebate. FERC entered into a long-term (20-year) full-service lease agreement with Greenebaum and Rose Associates in which utilities are included in the rental cost.

Economic Analysis

Due to the many energy-efficiency measures included in the building's design, all three HVAC plant options had projected energy costs per square foot considerably less than the average downtown Washington, DC office building, which is typically $2.15 - $2.24/ square foot. Ultimately, the development team chose gas-electric cooling and electric heat based on concerns about future electricity demand costs, confidence in absorption technology, operational flexibility based on fuel costs and availability, and a Washington Gas rebate. The HVAC system chosen for the building had a projected energy cost of $0.710/square foot, as compared to $0.792/square foot for the all-electric base-case scenario. Total energy costs for the entire building with the new HVAC system were projected at $1.926/square foot as compared to $1.998/square foot for the base case scenario.

The optimized hybrid gas-electric chiller-heater plant provides a net savings of about $60,749 per year compared to an all-electric cooling and heating system. This net estimate is based on avoided electricity consumption and demand charges, less the cost of natural gas and the absorption unit maintenance/service premium. Figure 5 summarizes the building's annual energy cost savings.

The first-cost premium for a 971-ton (3,398 kW) absorption chiller was estimated at $350/ton, or $339,850, after the Washington Gas Rebate. Based on a yearly net savings of $60,749, the chiller has a payback of approximately 6 years. Assuming a useful life of 20 years or more, the long-term savings potential of the hybrid system compared to a conventional all-electric system is substantial.

End-User Perspective

Building engineers tapped the energy-saving potential of Union Center Plaza IV as they became more familiar with the building, its load profile, and physical plant performance capability, and ways to cut energy costs by integrating technologies for maximum efficiency. While circumstances beyond the control of the development team led to specification and installation of a system that is substantially oversized, the fundamental integrated design principles were sound and the building owner is equipped to accommodate growth in energy demand.

The building owner feels the facility is well positioned to serve a more energy-intensive tenant in the future, such as a financial, insurance, or data processing center with larger cooling loads. "It's the most efficiently operating building in our portfolio," says Steve Braesch of Greenebaum and Rose Associates, the building's developer and owner.

***Figure 5.** Summary of Annual Energy Savings*

Cooling Produced	916,452 Ton-Hors
Avoided Cooling Electricity Consumption	549,871 kWh
Useful Heating Produced	423,600 Btus
Avoided Heating kWh Consumption[1]	124,150 kWh
Total kWh Savings[2]	$35,322
Total kW (Demand) and Savings[3]	$80,889
Natural Gas Cost[4]	$50,462
Absorption Maintenance/Service Premium[5]	$5,000
Net Savings	$60,749

Notes:

1. *Savings estimate based on Fiscal Year 2000 operations*
2. *Based on winter rate of $.045/kWh and summer rate of $.053/kWh*
3. *Based on maximum demand rate of $10.25/kW and on-peak demand rate of $12.55/kW*
4. *Based on natural gas rate of $0.524/therm*
5. *Estimated premium; provided by UCP Management*

Replicability

The Distributed Energy (DE) Program selects projects that are highly replicable, or that can be duplicated in applications with characteristics similar to DE Program-supported projects.

Replication potential can be assessed by looking at various factors of the market and the site, including:

- DE/CHP potential within market sectors and subsectors, e.g. classified by the U.S. Census Bureau's North American Industry Classification System (NAICS)
- Industry growth and drivers
- Barriers and incentives
- Load profiles, e.g., electricity and thermal energy utilization patterns
- Technical and economic feasibility of the DE/CHP system
- Capital investment payback requirements

Figure 6*. BAC cooling towers*

Several market analysis and DE/CHP feasibility studies that incorporate many of these factors have been completed. Analysis from the 2002 Integrated Energy Systems (IES) for Buildings: A Market Assessment report revealed that the potential building sector market for building-integrated CHP is almost 17 GW in 2010, growing to over 35 GW by 2020, and includes CHP systems with absorption chillers, engine-driven chillers (EDCs), and CHP-only systems. This market potential is based on achievable economics, where CHP provides a minimum payback of 10 years compared with conventional HVAC systems and purchasing electricity from the grid. The potential for CHP is highest in office buildings, with over 10 GW of total IES, including significant opportunities for CHP with absorption units and engine-drive chillers (45 percent of the office potential).

According to the 2002 Federal Energy Management Program (FEMP) market assessment report, CHP Potential at Federal Sites, the national potential CHP capacity for major Federal agencies is estimated to be 1,500 – 1,600 MW. Electricity produced with this potential capacity would represent approximately 13% of all electric use in the Federal sector. The Federal building types with the greatest CHP potential are hospitals, industrial facilities, and research and development (R&D) facilities.

Helpful Web Sites

- Distributed Energy Program
  www.eere.energy.gov/de/
- Mid-Atlantic CHP Application Center
  www.chpcenterma.org
- Federal Energy Management Program
  www.eere.energy.gov/femp/

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

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